

59819

ARCHIV
HULSE
no. 72

IDRC-Lib

59819

FOOD SCIENCE, FOR RICHER OR FOR POORER
FOR SICKNESS OR FOR HEALTH

PAPER PRESENTED TO IFST SUMMER SYMPOSIUM, YORK, ENGLAND
1 SEPTEMBER 1982

BY: JOSEPH H. HULSE, DIRECTOR, AGRICULTURE, FOOD AND NUTRITION SCIENCES
INTERNATIONAL DEVELOPMENT RESEARCH CENTRE, OTTAWA, CANADA

FOOD SCIENCE, FOR RICHER OR FOR POORER
FOR SICKNESS OR FOR HEALTH

PAPER PRESENTED TO IFST SUMMER SYMPOSIUM, YORK, ENGLAND
1 SEPTEMBER 1982

BY: JOSEPH H. HULSE, DIRECTOR, AGRICULTURE, FOOD AND NUTRITION
SCIENCES, INTERNATIONAL DEVELOPMENT RESEARCH CENTRE, CANADA

66342

"Scientists are too much obsessed with narrow specifics and techniques, and too little concerned about long term planning and the economic value of their research. They seem more intent upon impressing other scientists than in doing what is potentially profitable and useful."¹

Whether this comment from the President of a large North American food corporation, is true or false, the facts suggest it does not represent an isolated opinion among those who select the top executives of the food industry. Though some notable exceptions are evident in the ingredient supply industry - the allied traders who provide the spices, flavours and other minor ingredients, one finds remarkably few presidents of Canadian food processing companies who have migrated upwards from the research laboratory. It is of little consolation to food scientists that a similar trend is evident throughout North American industry. The route to the executive elite appears distinctly more favourable to accountants, economists and lawyers than to those of technical professional origins. According to Science Indicators, since 1950, among the largest 100 US companies the proportion of presidents with professional financial or legal qualifications has increased by more than 50%; the proportion of those with technical professional backgrounds has declined by nearly 15 percent. Consequently, in the biggest companies, in a nation which overall invests more in research than all the other free-world nations combined, senior executives with technical qualifications appear as a distinct minority.

To what extent scientists may be responsible for this state of affairs, and what remedial steps should be taken to reverse the trend will form the main burden of this presentation.

The views expressed in this paper are those of the author and not necessarily those of the International Development Research Centre.

This paper was originally published in the March 1983 IFST Proceedings and is reprinted by the International Development Research Centre with the kind permission of IFST and Taylor and Clifton Ltd.

ARCHIV
HULSE
no. 72

IDRC doc 426

Financial versus scientific management

While in no manner discounting the importance of sound economic planning and responsible fiscal control in both private and public sectors, a preponderance of power in the hands of accountants and economists is probably unconducive to long term scientific and technological development, which are the lifeblood of food processing and distributing industries. The hazard to scientific progress rests in the accountant's disposition towards short-term gain over long term development. Short-term gain makes a hero of the present president; long-term development may bring greater credit to those who come later. An excessive dependence on such indicators of managerial success as quick return on investment is intolerant of apparent technological failure; it seeks the avoidance of risk with consequent discouragement of those whose business it is to be imaginative and innovative. Concomitant is a preference to buy rather than to develop new technology. An evident first casualty of the quick-return-on-investment philosophy, particularly in times of stress, is the research laboratory. Between 1965 and 1975 investment in food research in Canada, as a percentage of the total value of food factory shipments, has fallen from 0.14 to 0.12. The present economic recession is doing little to reverse this trend.

The quest for an apparent quick return favours movement of corporate financial assets towards the acquisition of other companies rather than to investment in research and technological development. The assets of newly acquired companies may then be used, together with bank credit, to buy other companies, not infrequently increasing the total corporate inventory of long used if not obsolescent technologies, manufacturing equipment and facilities.

In North America recent corporate mergers have brought together some strange and seemingly uncongenial bedfellows managed by top executives who understand little of the essential nature and inner workings of their latest acquisitions. The high turn over, low unit profit patterns, characteristic of flour milling, oilseed processing, meat packing and many other food industries, at first sight appear unfavourable by return on investment criteria when compared with pharmaceuticals, energy generation, tourism and other higher flyers. In the consequent squeeze on the acquired food company to improve its profitability, the research and technical development departments appear among the first to suffer.

Though scientists in general and we food scientists in particular must accept some responsibility for the managerial ascendancy of the accountant and econometrician, it is arguably illustrative of a more widespread and pervasive pattern. A few years ago, during a period when in response to the generally

depressed economy the government of Canada imposed strict controls on new recruitment by government departments, the Auditor General's Department almost doubled in size. Similarly, in June of this year the Guardian reported that the present British government proposes to double the number of Civil Service accountants it employs.

Changing attitudes to science

During the late 1950s and early 60s science enjoyed universal glamour. In Canada, government and industry made regular visits to universities to compete for the best science graduates. The Director of the US Atomic Energy Laboratory at Oakridge described rockets and high energy accelerators as scientific monuments, equivalent as symbols of our time to the Cathedral of Notre Dame as a symbol of the Middle Ages.

In sharp contrast to what is illustrated by this hyberbole, and the glorious and limitless future predicted for scientists twenty years ago, the past decade shows evidence of a growing public disenchantment with science. In part it may have its origins in the more grotesque horrors of the Vietnam War. Today it is by no means confined to the technologies of massive human destruction. Beginning in the sixties publications that decry scientific threats to a safe food supply, to the environment, and civilization in general, have proliferated like dandelions in spring. Though many fail to present a balanced view, not all published criticisms of science and the scientist are totally misinformed. Rachel Carson's "Silent Spring" and "Hard Tomatoes Hard Times" by Hightower were critical of what they saw as an important limitation in U.S. agricultural research: too much emphasis upon the nature and interactions of soils, plants and animals; too little upon the concerns of consumers. Critical reviews came from scientists and others with a science connection. A former British Minister of Science and Education, writing in the Times in 1971, stated that "for scientists the party is over".

Critical interests of consumers

Judging by the space it receives in the popular press, nutrition seems as lively a subject in Britain as in North America. Not surprising among societies that enjoy previously unparalleled longevity, greatest interest is focussed upon food and the maladies that afflict older people. Cholesterol and cardiovascular disease, lignocellulose and carcinogenesis appear as newsworthy as sex, crime and moral delinquency.

The growing interest shown by consumers in nutritional quality is indeed to be welcomed and food industries must be prepared to provide relevant information that is sound and reliable. As professional people we could probably be more diligent in

counteracting false nutritional information put out by people more intent on gaining publicity than in advancing social welfare. Some appear to believe that the alchemists' elixir vitae is within human grasp. In the long run we shall enjoy wider credibility if we say we don't know, when such is the case, rather than adding currency to the belief that we can offer one diet that will eliminate coronary disease and another colonic cancer. To avoid causing unreasonable expectations, particularly among those in need or distress, food and nutrition scientists would be wise to approach each new nutritional panacea with more caution than enthusiasm.

That food and nutrition research tends to follow fashions is illustrated by the number of papers published on subjects of contemporary interest. During the 1960's fortification of cereals with lysine appeared to be in vogue. Since 1970 research interest in the subject seems to have died. Perhaps it became all too evident that much of what was reported was largely predictable: addition of lysine caused the rats to gain weight faster and accentuated the Maillard reaction.

Now "dietary fibre" appears as the in thing. According to the U.S. National Agricultural Library research literature data base (CAIN/Agricola), there were 12 published papers on the subject in the period 1970-73, 155 from 1974-77 and 287 from 1978-81. No doubt, literally and figuratively, fibre too will pass away. While food science will doubtless continue to help lengthen our lifespan, we should occasionally remember and remind those we serve of George Bernard Shaw's dictum: "Do not try to live forever. You will not succeed."

Food science - its benefits to humanity

Though they may have been denied, or perhaps in significant degree have denied themselves elevation to the highest positions of industrial power, food scientists and the many professions and disciplines they embrace can take pride in the remarkable contribution made to human welfare, particularly for inhabitants of the economically developed countries of Europe, North America and Oceania.

Nowhere are the social and economic benefits of science so sharply contrasted between rich and poor nations as in the post-harvest sector, the sequence that begins with harvest or slaughter and ends when the food is eaten (Hulse 1981a)². Food science has contributed immeasurably to the efficiency of post-harvest systems in developed countries, but much less so among poorer nations, a disparity with important consequences for the future. In spite of a climate which severely constrains crop cultivation and the period of harvest, most inhabitants of Canada all the year round can choose from several thousand grocery items to provide a diet which costs less than 18% of the average disposable income.

A safe food supply

Thanks to the pioneering work of Hassall in Britain, which laid the foundation of the world's first and all subsequent food and drug regulations; to Pasteur's reports to the Board of Hygiene and Sanitation in Paris; and, to the many scientists who came after them, Canadians and other North Americans, Britons and other Europeans have access to the best protected and wholesome diets in the history of mankind. "La vie est un fonction chimique" wrote Antoine Lavoisier in 1780. Indeed several generations of chemists have provided the knowledge of food composition and the analytical tools by which our regulatory agencies protect the consuming public against natural, accidental or intentional contamination of foods by toxins, anti- or non-nutrients. Deliberate adulteration, successfully practised by Canthare in Ancient Greece, reported by Pliny in Imperial Rome, and a matter of widespread concern from the industrial revolution onwards, is now far less of a hazard in Britain and Canada than in countries which lack adequate food legislative and control agencies. Consequently, if we are to retain our international credibility we, as professional scientists, should condemn in the strongest terms the practice of exporting additives for use in foods and foods containing additives which are proscribed and disallowed by legislation in the exporting country.

To some of its adversaries in North America and Europe food science appears primarily dedicated to the deliberate, deceptive and deleterious sophistication of processed foods. The advocates of "natural" plant foods appear unaware that cyanogenic glucosides may cause goitre, and in extreme cases cretinism, among many of the 300 million who subsist largely on cassava; that potentially toxic saponins occur in the indigenous chenopods and some potato genotypes important in the diets of South American Amerindians; that the procyanidin polymers found in the pericarp and testa of sorghum and, probably in a number of legumes, significantly reduce the biological value of the protein ingested.

Several member institutes of IUFOST have established imaginative programs of consumer information to inform the public at large of the benefits provided by scientifically controlled food industries. To address the whole subject of food and the consumer, IUFOST has created a committee under the Chairmanship of Dr. Richard Hall.

Dr. Hall, in a recent paper to the Canadian Institute of Food Science and Technology, presented interesting statistics on the pattern of food additive (GRAS) usage in the USA. Between 1960 and 1970 the rate of disappearance per capita of almost all food additives increased, a trend which though modified in detail, continued during the seventies. The data demonstrates the continued growth in consumption of industrially processed foods. Though the

greatest rate of growth was in acidifying and leavening agents, the sweetening agents: sucrose, corn syrup and dextrose, were consumed in greatest per capita quantities followed by salt, mono and diglycerides (about 0.5 kg per person per year) modified starch and yellow mustard. Dr. Hall pointed out that of the more than 2,000 intentional additives, the median annual per capita use in the USA is 1 microgram.

As Dr. Hall pointed out, it is difficult enough to demonstrate absolute safety of new microingredients with the analytical and biological tools available. It will be much more difficult to demonstrate in the laboratory the absolute safety of totally unfamiliar food production systems derived, for example, from unique biotechnologies.

Information to the general public

In 1945, Sir Henry Tizard, then President of Magdalen College at Oxford asked the question "I wonder if the part that scientists have played (during World War II) will ever be faithfully and fully recorded. Probably not."

Equally one might beg leave to doubt that the part science has played in providing the world's privileged minority with a safe and more than adequate diet will ever be comprehensively recorded. Nevertheless food scientists in government and industry could be more forthcoming in explaining the contribution of food science to economic development and social welfare and the manner in which the combined skills of chemists, physicists, micro-biologists, nutritional biochemists, engineers and many other scientific professions have made possible the definition, implementation and monitoring of food quality standards that safeguard the health and wellbeing of Britons, Canadians and most of the rest of the developed world.

Origins of food science

It is difficult to fix a date when food science was first recognized as a discrete discipline, though its components have long been in evidence. One of the first comprehensive university degree courses in food science, in fact though not in name, was started in 1923 by T.K. Walker at what is now UMIST. S. Walter Butterworth, well known in Leeds, was one of the first graduates.

It is intriguing to speculate how much sooner food science might have been established had the alchemists been more rationally informative. It would be unfair to equate contemporary efforts at communication by food scientists with the alchemists' deliberate paradoxes and principle of dispersion: maximum words to convey minimum meaning. Nevertheless, those of us who are its practioners

might well devote more thoughtful effort to explaining modern food science and technology to all whom they seek to serve and benefit. If we appear to accept Maimonides' philosophy that in theology and science there are topics that should never be explained we shall for evermore be reacting and responding defensively to unfavourable criticism.

Food Science - its historical antecedents

It is not generally appreciated that, in sharp contrast to the electronics and other high technology industries, the traditional technologies of food preservation and transportation long preceded any scientific understanding of their inherent nature and consequences. Peking man ground grains, crushed berries and cooked his food. Alcoholic and panary fermentation were common around the Mediterranean 6000 years or more before Buchner and Emil Fischer laid the basis for enzymology, and Pasteur, while studying a disease in silk worms gave microbiology its origins. Seneca described how Romans preserved shellfish in packed snow from the mountains. Termites used evaporative cooling to air-condition their mound dwellings thousands of years before Joule and Kelvin identified the principle upon which refrigeration depends.

The Amerindians practised solar dehydration including atmospheric lyophilization of potatoes. They also used running streams to elute out the toxic cyanogenic-glucoside linamarin from cassava and the saponins from potatoes, quinoa and other edible seeds. (Interestingly, West Africans, presumably empirically, discovered that the toxin in cassava can be eliminated first by allowing the fresh root to ferment, which permits the Geotrichum and Propionobacter from the soil to lower the pH to a level at which linamarinase hydrolyzes the linamarin. The HCN generated is then removed partly by pressing out the free liquid, the residue by toasting or by steam distillation from an open cooking pot.)

The justifiable publicity given to Australian ingenuity in storing cereal grains in 25,000 tonne gas-tight silos under an atmosphere of CO₂ generated by dry ice pellets, reminds one that 5,000 years ago farmers in Egypt, and on territory that is now Saudi Arabia, controlled infestation by covering and sealing each grain-filled amphora with a goatskin. The CO₂ generated by respiration effectively asphyxiated all predators present.

Food Science - Its complexity

Food scientists have been, are, and for many years will be devoted to a better understanding of the nature and composition of food materials and the changes they undergo post-harvest and during such traditional transformations as fermentation, milling, drying,

frying, baking and boiling. The general public is largely unaware that the biological raw materials of the food scientist are more highly and uncontrollably variable than those of the inorganic chemist; that the properties and composition of all cultivated plants and animals vary significantly under the influence of their genetic background, the environment in which they are raised, and the conditions under which they are harvested, slaughtered, stored and processed; that the biochemical and biophysical changes which occur at various stages of growth and post-production, particularly during processing, are so immensely complex it is often impossible to isolate any one from the many that are progressing simultaneously.

Whereas about 80,000 different edible plants have been recorded, only about 50 are cultivated to any extent; almost 90% of the world's harvest comes from about a dozen plant species. It will therefore be a long time before the food scientist can write "FINIS" to research to elucidate the nature, composition and potential utility of the world's food sources.

It is not widely appreciated that though the tools exist to analyze most of the major and minor nutrients and anti-nutrients in people's diets, chemistry alone cannot determine nutritional adequacy. Though the adverse effects of grossly excessive or inadequate nutrient intakes are usually demonstrable, what constitutes the ideal diet for any condition of man, woman or child is far from certain or universally agreed upon. Any recommendations of how much protein each of us needs could well be entitled "the protein pendulum". Among early workers, estimates for healthy adults varied between 119 g, prescribed by Playfair in 1865, to 46.5 g per day by Hirshfeld in 1889 (Hulse 1981b)³. Among international expert committees, estimates of daily adult requirement vary from (a) not less than 1.0 g/kg of body weight to (b) 0.57 g/kg prescribed respectively by (i) the 1935 League of Nations Committee and (ii) the FAO/WHO 1971 Expert Committee on Energy and Protein Requirements. Scrimshaw (1976)⁴ has questioned these latter recommendations, particularly as they affect those suffering or recovering from acute disease.

Food science and human labour

Of all the many benefits derived from food science by North Americans and Europeans, most evident and quantifiable is the progressively reduced labour demand at all stages of the food system. The time absorbed by human labour in production, processing, control and distribution has been reduced by several orders of magnitude since our grandparents' time. In that much of the process of change is attributable to adaptive engineering and the replacement of men and women by machines, food technology in the 20th century might be considered an extension of the earlier

industrial revolution. Mechanization both in the factory and the food laboratory have been attendant upon a more precise understanding of the nature and composition of foods and the changes they undergo, which explains, at least in part, why the food industries were slower to mechanize than the textile industries in Yorkshire and Lancashire.

Of greatest significance to the greatest number has been the pre-processing and greater convenience of use provided by the food industry to the homemaker, particularly to the working parent. No other science has done more than food science to permit both parents, in many households, to pursue full time professional careers without detriment to the adequacy of the family diet. In contrast, to the relatively short food preparation time demanded of most North Americans, the rural women of West Africa spend about 10 hours every day in grinding grain, and collecting wood and water with which to cook it.

Thus, though they are not readily evident in the industrial seats and governmental corridors of power, food scientists have not been idle in serving the interests and welfare of about one-third of the world's people. Nevertheless, if they are to bring desirable benefit to all humanity, food scientists must in the future equip themselves for a greater share of senior management, to take their place in positions of influence in planning and directing food industrial policy and practice.

Changing patterns of consumption

The post world war period has witnessed remarkable changes in North American and European life styles. In Canada, between 1960 and 1980, family expenditures on food increased more than three fold, faster than the increase in the overall Consumer Price Index, but at a slower rate than the average family's disposable income. The growth in food costs reflect a higher per capita consumption of processed foods (the real, i.e. constant dollar growth in Canadian food processing industries being about 3% per annum) and of relatively more expensive items such as meat, fruit, vegetables, vegetable oils and alcohol. The proportion of dairy and cereal products significantly declined, the former largely in response to adverse publicity concerning cholesterol and its suggested relation to animal fat. Between 1974 and 81, the literature contained some 81 research papers on cholesterol in the diet.

Two years ago it was predicted that these consumption trends would continue through the 1980s. It was also specifically forecast that within ten years 50% of all Canadian meals will be cooked outside the home. Whether the effects of the present economic depression will modify the trend, or whether the savings in energy consumption realized by large scale cooking over home-preparation

will be sufficient to accelerate out-of-home-cooking trends remains to be seen. Whichever, it seems not improbable that the market share enjoyed by fast food dispensers is more likely to expand than to decline. Herein lies a challenging opportunity for technological imagination and ingenuity if we are to be spared a diet dominated by hot dogs, hamburgers and fried chicken.

Of particular concern to the food scientist in industry are the demographic changes gradually taking place. The birth rate in Canada is about 1.7 births per female resident which, without immigration will result in a declining population. The median age has increased to 29 years from 20 in 1900 and is forecast to reach 36 by the end of the century. During the past five years the number of children under 15 years of age has dropped by 7% and those over 65 have increased by 17.9%. These trends, probably not dissimilar to what may be expected in Britain, Western Europe and the USA, strongly indicate a near zero increase if not a decline in total food consumption since old people generally eat less than teenagers.

Competition, survival and management

Thus any growth in one sector of the food industry will be at the expense of another sector. Also evident is a marked reduction in the variety and number of processed foods offered for sale by Canadian supermarkets. Intra-industrial competition will therefore inevitably intensify not only within but among countries and only the fittest will survive. The fittest companies are those equipped to use their technological resources most efficiently; those who employ research to stimulate ingenuity, adaptability and flexibility; certainly not those who incur heavy high interest debt to proliferate multi-corporate dinosaurs. Managerial myopia intent exclusively upon short-term gain must give way to the longer wider vision of those with the light of science in their eyes and a flame of creativity in their souls.

Perhaps following the observations of the Rothschild report in 1971, the management of food and agricultural research in Britain is now safely in the hands of competent scientific managers. Such is not the case in many countries where a new breed of food scientist in industry, government and the universities is clearly necessary: men and women who are as intent upon seeking out what is potentially useful and profitable as with astonishing other scientists; who formulate their research projects in the light of identified economic and social need rather than what is the fashion of the moment. Industry and government will need people who are as much disposed towards the management of science as with its techniques and gadgets; scientists able to plan and direct food research strategically and tactically; to comprehend and foresee the outcome of each research project in its total social economic context and environment.

Operations research

The strategy will call for both medium and longer term planning. Medium term research might best concentrate upon gaining a more accurate comprehension of existing operational systems as a precedent to the improvement of operational efficiency. Food and other biotechnological industries will need research managers who combine food science with a knowledge of operations and systems research methodologies. The high cost of energy from fossil fuels and other sources has stimulated energy audits in many Canadian food enterprises. This is not surprising since, of the total energy to maintain the Canadian food chain, agricultural production consumes only 18% while (a) processing and packaging, (b) transportation and distribution, and (c) home preservation and preparation absorb respectively 32, 20 and 30 percent.

Professor John Hawthorn, the Chairman of IUFOST's Committee on Energy has suggested that a universally standardized system of energy audit in food systems is needed to permit reliable inter-industrial and international comparisons.

Operations research offers several advantages to the industrial food scientist. First and foremost the results are quantifiable and demonstrable to those who base judgement upon cost versus benefit. Second, by a continuing critical analysis of existing systems and resources, operations research provides a rational basis for future long term product and process research priorities. Third, it stimulates a continuing working relation among food research scientists, process engineers and factory workers thereby increasing their collective perception, interest and productivity.

In some companies operations studies are regarded as the prerogative of the factory engineer. While the cooperation of the engineers, indeed of all production staff is essential, the overall improvement of operational food systems requires the intellectual disposition of food research scientists who combine biological understanding with the systematics of operations research.

Food scientists will need several new weapons in their professional armory not least being the concepts and techniques of technological forecasting: the qualitative and quantitative appraisal of future technological need, the time and resources required, and the opportunities and constraints to its adoption. Though they offer neither an infallible royal road to success, nor the means to self-fulfilling prophecies, the concepts and practices of technological forecasting deserve serious study by all engaged in food research and development.

Planning long-term research

In the non-expanding, highly competitive food markets of the future, longer-term research to develop successful new products and processing technologies will demand an unusual degree of thoughtful well-planned innovation. The understandable pursuit of liberation from culinary drudgery, combined with continued growth of consumers' disposable income, fostered a ready market for the three-decade-long processing of convenience foods, many of which could be manufactured by modification and adaptation of well-established technologies.

Though, for the demographic and economic reasons already manifest, the total food market will probably not expand, certainly not at the rate of the baby boom years, the pattern of demand will inevitably change. Imaginative research will therefore be in greater not lesser demand. A changing market, with shifting proportions in age and disposable income group segments is a market for optimistic innovation, not for pessimistic retrenchment. Those who understand and react to the changing demand will survive and prosper. Those who don't will go under.

Market demand research will require more reliable methods of appraisal, analysis and prediction to determine the nature and dimensions of the opportunities for, and constraints to the acceptance of new products. Canadian and no doubt British consumers are better informed than were their grandparents, to whom fibre was a constituent of underwear which caused irritation during long Sunday sermons.

It is to be welcomed that the present day consumer is concerned not only about price, convenience and utility but also with nutritional quality. This is the domain of the food scientist whose expertise is needed in both market research and in deciding the manner in which each new product is promoted and presented.

Though market research to assess consumers' tastes and attitudes is essential to the definition and development of food products, it cannot be the only guiding criteria for useful and profitable innovation. Consumers may envisage a modest extension or modification of what already exists. It requires scientifically inspired imagination to conceive what might be; to plan and direct the longer term generation of new and more efficient food systems and processing technologies.

Linear versus systems concepts

Given the restricted opportunities for growth and the relatively high investment risk of establishing original and novel processes, innovations will likely encounter many obstacles particularly where a short-term-gain-on-low-risk-investment

philosophy prevails. To stimulate adoption and application of new technologies many scientists and scientific institutions may need to adopt a different approach to what has been their custom.

Though earlier successful instances may be cited, the linear concept and pattern of research and development, starting with an idea in a laboratory, progressing to the pilot plan and then to production, is by no means an infallible model. It reflects in large part Emerson's (or Hubbard's) disputable better mousetrap theory.

The linear model was, and in some places still is the pattern for agricultural research: a new genotype or cropping combination, developed on an experimental farm in due course is presented to an extension officer eventually to be carried to the farmers' fields. What now appears more reliable is a systems research methodology which begins on the farms with the farmers who are to use and benefit from the research. A detailed study determines and measures the existing farming system covering relevant environmental, technological, social and economic factors in order to understand the opportunities and constraints to adoption of new technology and, most critical, to decide what new or improved technologies appear desirable and applicable. The technology is thus developed and applied by a cooperative partnership between scientists and farmers. The cycle that begins with an assessment of the farmers' existing resources, and by applied research continually expands that resource base, is not dissimilar in concept to the concentric system of teaching devised by the Yorkshire educator Professor Bellamy. What is fundamental is that the research must be preceded by a thorough understanding of the needs and opportunities of those who are to use and benefit from the research, and of the physical, social and economic environments in which they work.

The Chorleywood Process, one of the outstandingly successful examples of research that brought about a fundamental change in a traditional food technology, illustrates the wisdom of first determining an urgent industrial need before embarking upon the development of a new technology. Though the discovery that mechanical development would tolerate a weaker wheat blend was perhaps serendipitous, the primary objective: to eliminate bulk fermentation, resulted from a clear concept of the needs, opportunities and constraints of the British baking industry. Questioning the inevitability of a technology, that in basic principle had existed unchanged for 6000 years, illustrated how effectively science can and should serve industry.

Scientists in management

C.P. Snow in "Science and Government" (Harvard University Press 1960) describes some scientists as gadgeteers, too much obsessed with the inner workings of their inventions, too little with trying first to understand who needs new technologies and for what purpose. He goes on to deplore that many scientists are too much concerned with detail and too little with broader issues to be competent managers or administrators as he prefers to call them. This criticism is echoed by Sir Roger Falk in "The Business of Management" (Pelican 1970). In response to the argument that science is too important to be left in the hands of scientists, Snow responds that science cannot be planned and directed by "the scientifically illiterate". Snow's comment, made with reference to scientists in the government service, applies equally to scientists in industry. Until they become recognized and trusted as competent managers, at the highest policy making and directing levels, food scientists will never contribute to society what they are fully capable of.

Francis Bacon wrote that "a wise man creates more opportunities than he finds", and in another context: "If we start with certainties we shall end with doubts; but if we begin with doubts and work patiently, we shall end with certainties."

At the present time pessimistic doubts about the future are legion. Forecasts of static or declining consumer populations, combined with the lower consumption and disposable income patterns typical of aging populations do not stimulate cheerful optimism among the accountants who control our industries and the bankers who finance them. Indeed the changing demographic economic and social patterns of North America and Europe are not to be lightly discounted by those who plan and direct national food supply and distribution systems. The food industry can however take comparative consolation in the knowledge that while an aging population promises a bearish market for baseball and cricket bats, we shall all need food until our last breath.

The difficulties will not be overcome, nor the many opportunities realized either by governments or industries acting independently of one another. Britain possesses the notable advantage of its jointly financed research associations. In all countries, however, much greater integration and cooperation between industry and government in long-term planning of food research and development is essential. The conversion of results from government food research laboratories into viable industrial technologies appears generally spasmodic and in many instances disappointing.

Food science and development

To this point food science has been considered largely in relation to what it provides for the world's privileged minority, the nations, inhabited by less than one-third of the earth's population, which carry out and control more than 90% of all the world's research and which enjoy an enormously favourable balance of trade (about \$70 billion in 1976) over the poorer developing nations. Though the difficulties of providing a safe and adequate diet for the more than 3 billion people in the developing world, plus the extra million who are born every five days, may seem insurmountable, the opportunities for the innovative food scientist are beyond belief. Africa, Asia, Latin America and the Near East are the regions of greatest growth in future food demand. Their total populations are increasing at more than 2% per annum, the greatest proportional increase being in the urban complexes where the need for preserved and processed foods is greatest.

By adapting the agricultural technologies developed in the international agricultural research centres and by raising national investments in agricultural research, many nations in Asia, Latin America, the Near East and, to a lesser extent, in Africa, show promise of a significant increase in food production. Much less evident are the reliable post-production systems needed to protect, conserve and safely distribute the products of agriculture from the regions and seasons of abundance to those of scarcity. While food science has provided immeasurably to the welfare, comfort and pleasure of the wealthier minority, its impact on the lives of the poorer nations is markedly less evident (Hulse 1982)⁵.

This is not to suggest that industrialized food technology does not exist in the developing world. Wheat flour mills, breweries and bottled pop factories are to be found in some of the poorest countries. But many of these and other food industries are located in urban centres and function largely with imported equipment and raw materials. In tropical countries climatically capable of raising crops during most of the year, there exist enormous unexplored opportunities for food processing and distributing industries in rural areas using technologies congenial to the physical, social and economic environments. It is in the rural communities where the food is produced that technically reliable and economically sound systems of preservation and distribution are most urgently needed. In the light of the rapidly growing rural and urban populations of Africa, Asia, the Near East and Latin America the opportunities for cooperation between food scientists in these regions and their counterparts in Europe, North America and Oceania are indeed exciting to contemplate.

Cooperation between the richer and the poorer

To stimulate such cooperation the Governments of both Australia and Canada have recently legislated new mechanisms within their respective countries. The International Council of Scientific Unions (ICSU), of which IUFOST is an Associate Scientific Member, has created an international Commission on the Application of Science to Agriculture, Forestry and Aquaculture (CASAFA) whose primary purpose, also, is to identify and encourage cooperative research ventures in food and agricultural development.

Whether between governments or between industries, one partner in a developed, the other in a less developed country, cooperative undertakings must be planned and committed on a long term basis. Such ventures are unsuitable for those who seek a rapid high return on a short term investment. Comprehensive market research is just as vital in North Africa as in North America before food industries with a long term viability can be established.

Over the past quarter-century multilateral and bilateral agencies have financed many programs in food industry development and technical assistance. The reasons why not all have achieved original expectations are many and varied. There is no simple formula which will guarantee success. One of the more evident sources of disappointment derives from an untoward and unrealistic belief in the transfer of technology. Technologies based upon inorganic chemistry or electronics are fairly readily transferable between countries of different environments. Food and agricultural technologies are not easily transferred between northern temperate and southerly tropical nations, first because the biological materials involved at all stages of production, processing and distribution are conditioned by the prevailing physical environment; second, because food acceptance is so greatly influenced by the prevailing social and economic environment.

Food science is virtually unique in that it is both a technical and a social science. The underlying scientific physical, chemical and biological principles are universally valid and transportable. The social and economic factors are specific to localities and communities. Consequently, food technologies must be developed and adapted where they are to be applied, in close cooperation with those who are to use and benefit from them.

This philosophy should be self-evident to any food scientist familiar with market research. It is evidently not universally accepted by all administrators of technical assistance programs or by all who formulate national policies in developing countries. It is seemingly not evident to those large food companies and bilateral assistance agencies who persist in trying to press their square peg technologies into the round holes of developing country needs. For

some it appears that all will be well simply by qualifying "technology" with "appropriate", an adjective more inappropriately used than most others.

The linear concept of research and technology development, referred to earlier, is evident both in the efforts to transfer food technology from the North to the South, and in the external financing of food research and development institutions in developing countries. Several food research institutions in developing countries were modelled on institutions existing in Europe or North America, and equipped with apparatus from donor countries, before any clear research priorities had been defined. The inevitable consequence was that the subsequent programs of research were dictated by the equipment available, not as a rational response to demonstrable needs and opportunities.

The IUFoST Committee on the Needs of Developing Countries (CNDC) has drawn attention to the difficulties experienced by food research institutions established in large cities in addressing the opportunities and difficulties in the rural post-harvest sectors. Evident in many countries and widely documented are the problems of translating results from government research laboratories into industrial technological practice. The transfer of technology from government to industry within a nation is far from easy; unless government research is designed and directed to satisfy an identified social need and economic opportunity no such transfer is possible.

Food research: for whose benefit?

During the past 11 years the International Development Research Centre (IDRC), with its headquarters in Ottawa, has supported close to 500 applied research projects in agriculture, food and nutrition sciences in over 70 developing countries. A question always asked of the food and agricultural scientists who request IDRC's support is "whom is the research intended to benefit and how will the benefit be realized?". Is not this a question which every food scientist, whether in government, industry or a university, should answer before his or her research or development project begins? Is not this the fundamental question of scientific management: what business are we in and whom do we seek to benefit? Who are the clients for the products of our ingenuity?

These questions are equally germane whether the research is intended to generate a new, or to improve an existing technology; or if it is to explore the changing nature and composition of food materials as they are stored or processed. At least 80% of Canadians who graduate in food science are eventually employed in industry or the government service, both of which are complementarily responsible for providing the nation with an adequate,

wholesome, economic and pleasing diet. Since all of food science is, or should be, largely devoted to human interest and social well-being, it is by social and economic criteria, not simply by scientific ingenuity, that food scientists should set their standards and by which food science will in the final analysis, be judged. Though dissemination of research results is essential, a paper in a reputable journal should not be the solitary end-point of food scientists' labours, nor the only yardstick by which scientific performance is judged.

Assessment of scientists

In government and industry the "evaluation" of scientists and scientific productivity appears as widely interesting and debated as dietary fibre. A confidential survey of several Canadian food industries with sizeable research departments revealed wide variations in the way in which their scientist employees are judged and assessed. Some companies conduct very formal annual evaluations with questionnaires and structured interviews; others make their assessments (if at all) very informally. One well known international company has twice within the memory of the research director swung between the extremes of structured formality and casual informality. Government departments and agencies in different places display comparable variability in the criteria by which scientific innovation and effectiveness are judged and evaluated.

It is not unusual to meet scientists who view all attempts at performance evaluation with impatience if not contempt. Nevertheless, as economic pressures intensify in industry and the number of accountant auditors in government increases, more searching evaluations of human resources are inevitable. It is important, therefore, that food scientists give serious thought to how best their contributions to industry and government should be reliably evaluated. This is one of the many aspects of scientific management which the IUFOST Committee on Research Management has been asked to address.

Management by scientists

The social and technical objectives of food science are not incompatible; they are interdependent. An economically viable and socially acceptable food system derives from sound scientific judgement and management: professional management by people who comprehend the essential underlying scientific principles, the technological opportunities and constraints, the social and economic environments by which truly appropriate technology is conditioned.

Lord Kelvin wrote "If you can measure that of which you speak and can express it by number you know something of your subject. If you cannot measure it your knowledge is unsatisfactory". Scientists

being trained to measure accurately, and to analyze and predict reliably from their measurements, would appear as well qualified as accountants to be trusted to manage. The mysteries of the account ledger, calculations in pounds and pennies or dollars and cents are no more complex than computations of the widely diverse units which are food scientists' stock in trade.

Scientists' dedication to objectivity is sometimes advanced as a character indisposed to rational consideration of the many subjective matters that relate to decisions about people and social issues. There seems little evidence however to substantiate the view that scientists are less endowed than the rest of humanity with social conscience and those qualities of consideration and compassion essential to responsible and effective management.

If they are to fulfill their potential role as competent managers in government and industry, greater numbers of food scientists will need to be trained in the relevant philosophies, principles and practices of management. Though specialized training in post-graduate and shorter intensive courses is a paramount necessity, some of the basic considerations could profitably be included in the introductory lectures to undergraduate students in food science. A basic philosophy of management at the outset helps to place subsequent instruction in theory and practice into a more meaningful context.

Training in the management of food industries and research is of most pressing urgency in developing countries. As a modest contribution, IDRC, in cooperation with IUFOST's committee on research management, will convene the first of a series of working group seminars on food research management in October 1982. Participants will include past and present directors of research from private and parastatal industries, from government and government-industry research institutions in Africa, Asia, the Near East, Latin America, North America, East and West Europe. A few months later the second cycle will consist of simultaneous research working group seminars, one each in Africa, Asia and Latin America linked by MICOM. Taking advantage of the intervening time lags, every evening a summary of the day's proceedings will be transmitted from each of the three regional meetings to the other two.

A representative of the United Nations' University will be included in these research management exercises and it is hoped that in cooperation with UNU and other agencies, IDRC and IUFOST will make available to a greater number of scientists in developing countries training in the management of food research and industrial development. Food scientists, who are competent managers, are a necessity if technically reliable and economically sound post-harvest systems, including viable food industries are to be efficiently established and managed in the many developing countries where they are needed.

The majority of the world's people are employed in food and agricultural production, processing and distribution. Food science is the most vital of all sciences. People who are dying of starvation, who are physically and mentally incapacitated because of malnutrition can neither purchase nor enjoy the products of other technologies. But for food science to satisfy mankind's most fundamental need requires that it be planned and directed by food scientists, men and women who complement their knowledge of scientific principles and practices with broader perspectives of social behaviour and economic opportunity.

Food science: a union of technical and social sciences

The title of this presentation (delivered at the University of York) is borrowed from the Exhortation in the ritual for the Solemnisation of Matrimony in the Anglican Book of Common Prayer. When Thomas Cranmer compiled the prayer book from the five different liturgies then in use at the Cathedrals of Canterbury, Sarum (Salisbury), Winchester, Hereford and York, it was largely from the York Liturgical Use that he adopted much of the Anglican marriage service. What originally read as: "for fairer or fouler" became: "for better, for worse; for richer, for poorer; in sickness and in health."

If, universally, food science is to be for better, for richer, and in the best of good health, it must consecrate a lasting union between its technical skills and the socio-economic principles essential to successful management. Until food scientists accept the responsibility for the planning and management of food science, and its industrial application, mankind, and particularly those in greatest need, will never realize the full benefit of its potential and its products.

According to church doctrine the third cause for which matrimony is instituted and ordained is "For mutual society, help and comfort". What other profession is better able than food science to provide the help and comfort of which so much of human society is so seriously deprived?

REFERENCES

HULSE, Joseph H. (1977) "Research Management" in Agricultural Research Management, Volume II, Southeast Asian Regional Centre for Graduate Study and Research in Agriculture, Philippines

HULSE, Joseph H. (1981a) "Research and Postproduction Systems" in Advances in Food Producing Systems for Arid and Semiarid Lands, Academic Press Inc., England.

HULSE, Joseph H. (1981b) "Human Implications of Protein Utilization" in Utilization of Protein Resources, Food and Nutrition Press, U.S.A..

SCRIMSHAW, N.S. (1976) "Shattuck lecture: Strengths and weaknesses of the committee approach. An analysis of past and present recommended dietary allowances for protein in health and disease". New Engl. J. Med. 294, 136-142; 198-203, Jan. 15 and 22.

HULSE, Joseph H. (1982) "Food Science and Nutrition: The Gulf Between Rich and Poor" in Science, Vol. 216 No. 4552, June 18